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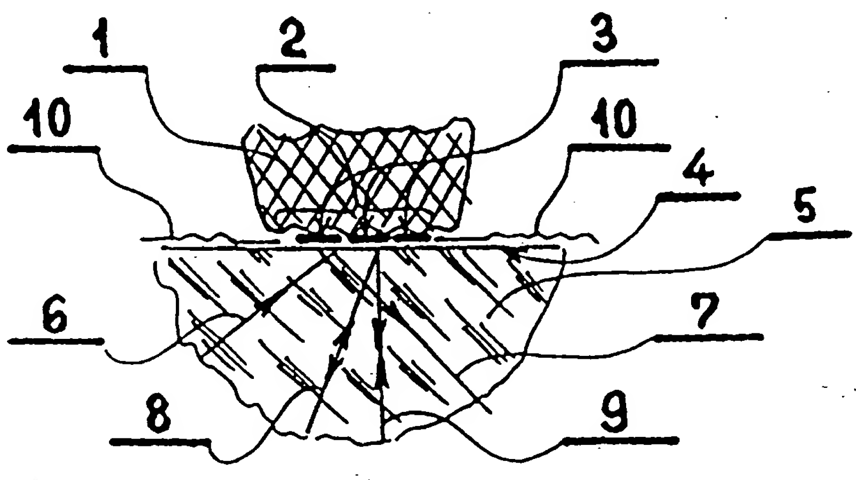


(57) Abstract

Detector for recognizing the living character of a finger which is arranged in a fingerprint recognizing apparatus and the detector is in contact with a print area (2) of the living finger constituting a print forming element (1) and the apparatus comprises for the examination of the print area (2) a print detector (5) which has a print imaging surface (4) partially covered by the print area (2). The detector comprises an electrode system (3) made of an electrically conductive material and sensing the presence of the print forming element (1), and an electrical evaluation unit coupled through electrical contacts (10) to the electrode system (3), the unit senses the change in state in the electrode system (3) caused by the proximity of the print forming element (1). The electrode system (3) is arranged on a portion of the print detector (5) covered by the print area (2) and it is coupled to the print imaging surface (4).

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# In a Fingerprint Recognizing Apparatus Detector for Recognizing the Living Character of a Finger

The invention relates to a detector for recognizing the living character of a finger which is arranged in a fingerprint recognizing apparatus. The detector is in contact with a print area of the living finger that constitutes a print forming element, and for the examination of the print area the apparatus comprises a print detector which has a print imaging surface partially covered by the print area, and the detector comprises an electrode system made of an electrically conductive material which senses the presence of the print forming element. The detector further comprises an electrical evaluation unit coupled through electrical contacts to the electrode system, the unit senses the change in state in the electrode system caused by the proximity of the print forming element.

The identification of individuals on the basis of fingerprint recognition has become recently a widely used technique. In case of conventional fingerprint analysis using a painted paper as well as in case of opto-electric fingerprint recognition systems the fingerprints are obtained when the tip of a finger is pressed against a surface. The modern opto-electric fingerprint recognition can take place under human supervision (e.g. when the fingerprint is entered in the criminal record) or without any supervision (e.g. in case of access control systems).

In case of fingerprint recognition without human supervision the fingerprint reading apparatus can be deceived by using a plastic imprint copy made from the finger of the person to be identified, thus a false access cannot be excluded. Therefore in case of protection or security systems as well as in systems permitting access to computer systems and in case of any similar application in addition to the fingerprint recognition it is also of vital importance whether the print has been taken from a living finger or from a copy. It is also important that the detection of the living character of the finger be fast and reliable.

There are known methods for detecting the living character of a finger. In the EP 0194783 A2 the optical spectral reflection coefficient of the finger is measured

at two wavelengths. The measurement of the reflection coefficient takes place at the two free sides of the finger pressed to the fingerprint recognizing apparatus. The quotient of the two reflection coefficients varies during the placement of the finger to the print area from a position where the tip of the finger just touches the surface till the fully pressed state. The detection of the living character of the finger is based on the detected changes of the quotient of the reflection coefficient. The drawback of this technique lies in that if a thin, transparent copy made by a thin film is placed on a living finger of another person, the change of the quotient of the reflection coefficient will be characteristic to a living finger, and a false detection is obtained. Such a system is used in the personal identification apparatus manufactured by the company Biometrics Technology as reported in "The Biometrics Report. ISBN 190018009, 1995. page 69".

In the Japanese patent publication 05309082 an example can be found wherein the measurements are based on the electrical resistance as one property of the print forming element. In this technique an electrode is provided which contacts the surface of the finger just below the first joint i.e. which is outside the area from where the fingerprint is taken. The electrode is used to detect the electrical resistance of the living finger. The resistance value depends on the humidity of the finger, and if this resistance falls in a predetermined range, the living character will be established. This identification is not reliable either, since the detection takes place at a location which differs from the location from where the fingerprint is taken. If a thin copy is placed between the finger tip and a print area, the contacts can still engage the living finger.

It can be understood from the above described known methods that they are inappropriate for the reliable detection whether the living finger belongs to the authorized person or not.

The object of the invention is to provide a detection system which can not only detect the living character of a finger but it is also associated with a fingerprint recognizing apparatus and it excludes false identification if the person is different from the one whose fingerprint serves as a basis for recogniton.

The reliable solution of the problem is based on the discovery that the recognition of the living character of a finger is determined by the evaluation of the electrical signals of an electrode system arranged within the print area of a print imaging surface when pressed by a finger and it takes place simultaneously with the recognition of the fingerprint.

Between the print forming element (finger) and the print imaging surface, preferably on this surface used as a carrier or being led out to this surface an electrode system is provided within the print area, and the material of the electrode system is electrically conductive to be able to provide appropriate detection signals. It is also preferable if the material of the electrode system is sufficiently light transparent not to disturb or limit the print recognition process.

The electrode system should have an appropriate pattern that enables detection and should be provided with electrical connections, and the electrode system can be covered at least in part by a thin light transparent layer.

An appropriate electrode system designed according to the above described principles will not disturb or limit the fingerprint recognition process and will enable the measurement of one or more properties or the changes of these properties of a living finger at the same time as the recognition of the fingerprint takes place. Such properties can be e.g.:

- electrical properties (dielectric constant, impedance, etc.)
- biophysical properties (points of acupuncture, reflex points, etc.)
- biochemical properties (pH, surface humidity, etc.).

A further preferable property of the detector according to the invention lies in that an increased reliability can be provided by combining several kinds of detection e.g. by using measurements taken from different surface areas and/or using an electrode system with combined patterns and/or measuring one or more properties or the variation of these properties, wherein multiple conditions can be defined for the determination of the living character of the finger.

The invention will now be described in connection with preferable embodiments thereof, in which reference will be made to the accompanying drawings. In the drawings:

Fig. 1 shows the detector according to the invention comprising an electrode system made of a thin layer on a print imaging surface;

Fig. 2 shows an embodiment of an electrode system which has a design other than using thin layers, wherein the electric connections can be seen;

Fig. 3 shows an electrode system covered partially with an insulating thin layer;

Fig. 4 shows an electrode system covered by a glass plate;

Fig. 5 shows an embodiment of a pattern of a single element electrode system used preferably for measuring the dielectric constant;

Fig. 6 shows a further pattern of a single element electrode system used preferably for measuring the electrical impedance of the print forming element;

Fig. 7 shows the pattern of an electrode system with three elements used preferably for the simultaneous measurement of dielectric constant and electrical impedance; and

Fig. 8 shows a multiple element electrode system and its pattern made from an electrically conductive and light transparent material for the simultaneous measurement of dielectric constant and electrical impedance.

The basic operational principles of the detector for recognizing the living character of a finger made according to the invention will now be described in connection with Fig. 1. In this Fig. 1 a print forming element 1 e.g. a living finger gets in contact with electrode system 3 of a detector along a print area 2 when pressed to the surface of the detector. The electrode system 3 is arranged on a print imaging surface 4 designed preferably as a planar surface of a print detector 5

The material of the print detector 5 is preferably optical glass or a transparent plastic material. When the fingerprint is imaged by means of opto-electrical imaging, the image of the fingerprint will be created primarily on the print imaging surface 4, and this image will be converted into an electrical signal sequence by means of a two-dimensional detector system (being preferably a CCD detector). When the imaging takes place by means of a total reflection method, illuminating light beams 6 and image forming light beams 7 are used. When the image forming is based on light diffraction, free path should be provided to illuminating light beams 8 and image forming (back-scattered) light beams 9. The role of these light beams 8 and 9 can be interchanged.

In Fig. 1 the electrode system 3 together with lead out contacts are designed as a thin layer electrode. The lead out contacts form additional parts of the electrode. The material of the electrode has a good electrical conductivity and preferably it is transparent at the wavelengths of the illuminating light beams 6 or 8. Respective electrical connections are coupled to the lead out contacts. The electrical connections can be made e.g. by metal wires. The wires can be contacted in a reliable manner e.g. by means of an ultrasonic thermal binding to the thin layer, by electrically conductive paints or by means of an epoxy-based adhesive filled with a plurality of tiny gold particles.

The literature describes several examples for making thin layers which are electrically conductive and at the same time light transparent. Such technologies include e.g. the use of chemicals, vacuum sputtering, vacuum evaporation or plasma techniques, and the structure of the electrode system 3 can be made by the conventional use of masks. The material of the layer can be e.g. the mixture of indium-dioxide ($In_2O_3$) and tin-oxide ($Sn_2O$) referred often to as ITO layer. Further layers like pure tin-oxide layers and mixtures including aluminum-zinc-oxides ($Al_2ZnO_2$) are also used. Such layers are not only electrically conductive and light transparent but they have the required resistance against mechanical and thermal loads. The typical thickness of thin layers falls in the range of 20 to 100 μm and their specific electrical resistance is in the range of $R\square$ = 250 to 1000 ohm $\square$ and

they have a sufficiently high light transparency (practically close to 95 %) When such layers are used, the full print area 2 can be imaged, since the presence of the thin layer cannot change the contrast of the detected image in any of the cited image detection methods using either total reflection or light diffraction. The contrast of the image of the fingerprint is typically 50-80 % and relative to this amount the additional contrast modulation of 5 % caused by the presence of the transparent thin layer is negligibly small.

The electrode system 3 of the detector can also be realized by using a thin layer which is not light transparent or which has only a limited transparency. Such thin layers are e.g. the thin metal layers made typically by gold, aluminum, chrome and similar metals. Such less light transparent layers are cheaper, however, their significant drawback lies in that the print surface sections covered by their structure cannot be imaged, thus such sections cannot take part in the identification of the fingerprint.

Fig. 2 shows an embodiment of the electrode system 3 together with electrical contacts 10 made without using thin layer technique. In this embodiment the pattern of the electrode system 3 is constituted by the fiber ends 12 of electrically conductive wires 11 embedded in the material of the print detector 5. The conductive wires 11 constitute at the same time the lead out wires. The electrically conductive wires 11 can be made either by thin metal wires or by glass fibers doped by metal ions. In the last mentioned alternative the additional advantages of light transparency will be obtained. In connection with Fig. 2 it should be noted that when the print imaging surface 4 is made (by means of grinding or polishing) the electrode system 3 constituted by the fiber ends 12 will form part of the print imaging surface 4.

In the embodiment shown in Fig. 3 the print forming element 1 is partially or completely insulated from the electrode system 3 by means of an intermediate electrically insulating thin layer 13, and the degree of insulation depends on the material property to be determined. If the insulating thin layer completely covers the electrode system 13, the print forming element 1 will reach the close proximity of

the electrode system 3. The close proximity means that the print forming element 1 will be in the electric field of the electrode system 3. In case of thin layers the corresponding distance is not more than a few micrometers. and the penetration is apparent. The required limit of proximity depends on the pattern of the electrode system, and in case of predetermined patterns several times 100 μm can be sufficient. The electrically insulating electrode system 3 is an important requirement when the measured material property is constituted by the dielectric constant.

The preparation of thin insulating layers is known from the state of art. Such layers are made typically by silicon-dioxide by vacuum deposition technique.

Figure 4 shows a further embodiment for electrically insulating the electrode system 3. The print imaging surface that carries the electrode system 3 is covered by an insulating cover sheet in such a way that the sheet is coupled to the print imaging surface 4 by means of an optical adhesive. Such optical adhesive materials are known in the art and they are transparent and have optical refraction indices close to that of glass, therefore they cannot cause undesired light reflections, i.e. a correct optical coupling is provided thereby. The presence of such a light transparent covering layer 15 will not prevent the illuminating light beams 6 and 8 from reaching the print detector 5 and from imaging the fingerprint. Obviously in that case the role of the print imaging surface 4 will be played by the surface of the electrically insulating cover sheet 14 that contacts the print forming element 1.

Fig. 5 shows the patterns of an element of the electrode system 3 used for measuring the dielectric constant. The pattern together with the lead out conductors is completely insulated from the print forming element 1 along the full surface of the electrically insulating thin layer 13. The pattern itself is a version of a so-called interdigital electrode 16 optimized for measuring the dielectric constant. The interdigital electrode 16 comprises a pair of oppositely arranged "comb" patterns. Such an electrode type is known for uses of other objectives and principles e.g. in the field of acoustic filters with surface waves. The typical size data of the electrode pattern used for measuring dielectric constant are: the line width of the comb lies between 5-100 μm and the spacing between the lines is between 5-100 μm. By

means of the interdigital electrode 16 it is possible to determine the dependence of the dielectric constant from the frequency. The size data of the pattern of the comb can vary according to the frequency range used. In practice the examining frequency range is between 0.1 and 200 kHz. In this frequency range the dielectric constant of living tissues largely differ from that of commercially available plastics (Hedvig P.: Applied Polymer Analysis and Characterization, Vol. II, Chapter 5., Hauser Publisher, Munich, 1992). The typical relative dielectric constant value of living body tissues is between about 60 and 90, while in case of plastics this value is between about 5 and 30. The difference is sufficiently large for the distinction of living tissues from plastics.

Fig. 6 shows the pattern of an element of the electrode system 3 used for determining the electrical impedance. The pattern represents the so-called double dot electrode 17 as optimized for electrical impedance measurements. The typical size of the sensor dots is between about 0.1 and 1 mm, and the spacing between the dots is 1 to 5 mm. The dots of the measurement dot electrode 17 are in electrical contact with print forming element 1, because respective open windows are made at the dot locations on the insulating thin layer 13 that covers the pattern, while the lead out conductors of the dots are electrically insulated from the print forming element 1.

Fig. 7 shows an electrode system 3 comprising three elements. Two of the elements constitute respective interdigital electrodes 16 while the third one is a double dot electrode 17. The size of the patterns of the two interdigital electrode elements can be different depending on the frequency range of the dielectric constant measurement. The use of multiple frequency ranges further increases the reliability of identifying living fingers. On the electrically insulating thin layer 13 that covers the electrode system 3 a window is provided for enabling impedance measurement as shown in Fig. 6.

Fig. 8 shows a preferable embodiment of the detector according to the invention that uses multiple element electrode system 3. The double dot electrode elements of the electrode system 3 are arranged within the print area 2 about 3 to

5 mm from the contour line, while the interdigital electrode element 16 is arranged in the central portion of the print area. In this exemplary arrangement the print area 2 is sufficiently covered by elements of the electrode system, and it can be prevented that a false copy that covers only a portion of the print area could cause an erroneous personal identification. Naturally, the number of elements in the electrode system 3 can be increased and several other patterns and arrangements can be made within the scope of the present invention.

The electrical contacts 10 of the elements of the electrode system 3 are connected to the inputs of an electrical evaluating unit 18. This unit 18 can determine not only the static values of certain material properties of the print forming element 1 but also for determining the variation of such material properties as a function of time. The measuring of such changes should be carried out preferably during the time between the print forming element 1 touches the print imaging surface 4 until it will be pressed thereto. The typical value of this time is between about 0.2 and 0.6 sec.

The electrical evaluation unit 18 generates an enable signal for the fingerprint identification or it provides data for the central processor unit of the fingerprint identifying apparatus and this unit enables the identification by analyzing the data obtained. Such an electric evaluation unit can be designed in several ways as it is obvious for those familiar with the measurement technique using micro controllers.

CLAIMS

1. Detector for recognizing the living character of a finger which is arranged in a fingerprint recognizing apparatus and the detector is in contact with a print area (2) of the living finger constituting a print forming element (1) and the apparatus comprises for the examination of said print area (2) a print detector (5) which has a print imaging surface (4) partially covered by said print area (2), and said detector comprises an electrode system (3) made of an electrically conductive material and sensing the presence of the print forming element (1), and an electrical evaluation unit (18) coupled through electrical contacts (10) to the electrode system (3), said unit (18) sensing the change in state in the electrode system (3) caused by the proximity of the print forming element (1), **characterized** in that said electrode system (3) is arranged on a portion of said print detector (5) covered by said print area (2) and being coupled to said print imaging surface (4).

2. The detector as claimed in claim 1, **characterized** in that the electrically conductive material of the elctrode system (3) and said electrical contacts (10) are made by thin layer deposited on said print imaging surface (4).

3. The detector as claimed in claim 2, **characterized** in that the electrically conductive material of the elctrode system (3) is light transparent.

4. The detector as claimed in claim 2, **characterized** in that the electrode system (3) is at least partially covered by a thin layer (13) of electrically insulating material.

5. The detector as claimed in claim 4, **characterized** in that the insulating thin layer (13) is light transparent.

6. The detector as claimed in claim 1, **characterized** in that that the electrode system (3) comprises fiber ends (12) of electrically conductive wires (11) embedded in the material of said print detector (5) and said fiber ends (12) forming part of said print imaging surface (4).

7. The detector as claimed in claim 6, **characterized** in that said electrically conductive wires (11) being metal wires or glass fibers doped by metal ions.

8. The detector as claimed in claim 2, **characterized** in that the electrode system (3) is covered by an electrically insulating cover sheet (14), and between the cover sheet (14) and the print imaging surface (4) a light transparent covering layer (15) is arranged for providing an optical coupling.

9. The detector as claimed in claim 1, **characterized** in that said electrode system is designed for determining dielectric constant and being constituted by interdigital electrodes (16) covered by a thin insulating layer.

10. The detector as claimed in claim 4, **characterized** in that said electorde system is designed for determining electrical impedance and constituted by at least one double dot electrode (17), and the electrically insulating thin layer (13) leaving said double dot electrode (17) uncovered while covering the lead out contacts of the electrode (17).

11. The detector as claimed in claim 1, **characterized** in that the electrode system (3) comprises a plurality of identical elements and said elements being arranged in a non-overlapping manner for identifying different portions of the print forming element (1).

12. The detector as claimed in claim 1, **characterized** in that the electrode system (3) comprises a plurality of different elements for determining different material properties of the print forming element (1) or the change of such properties as a function of time.

Fig. 1.

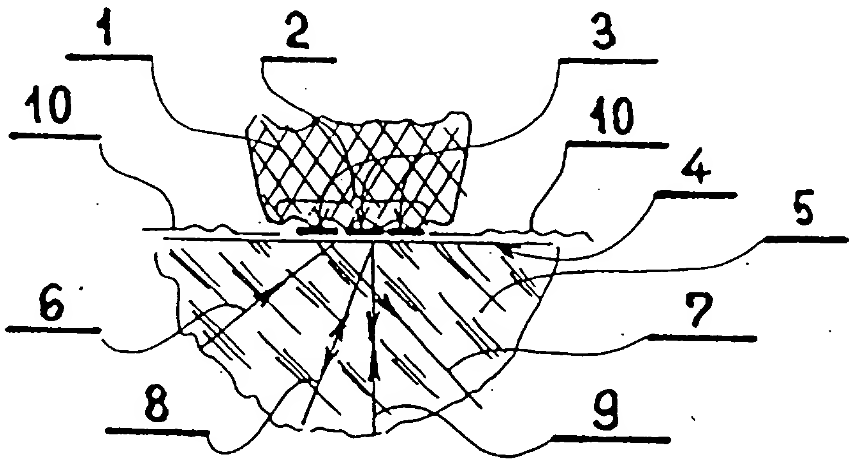
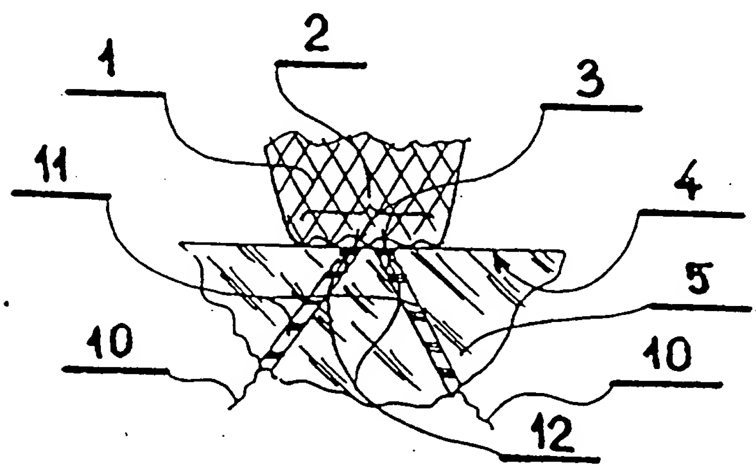



Fig. 2.



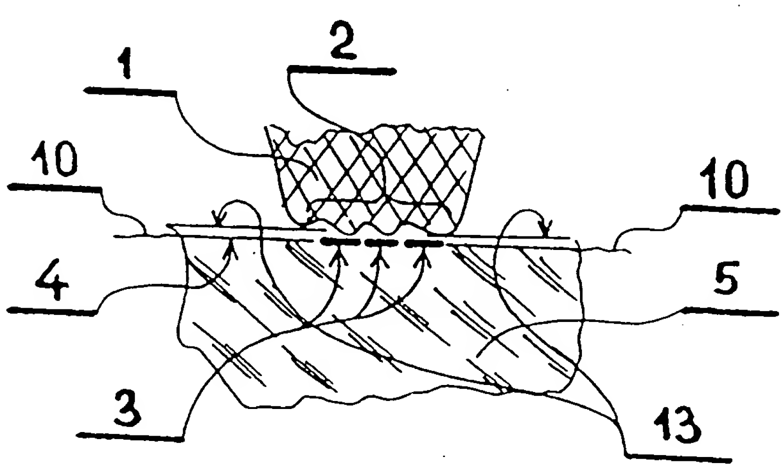




Fig. 3.

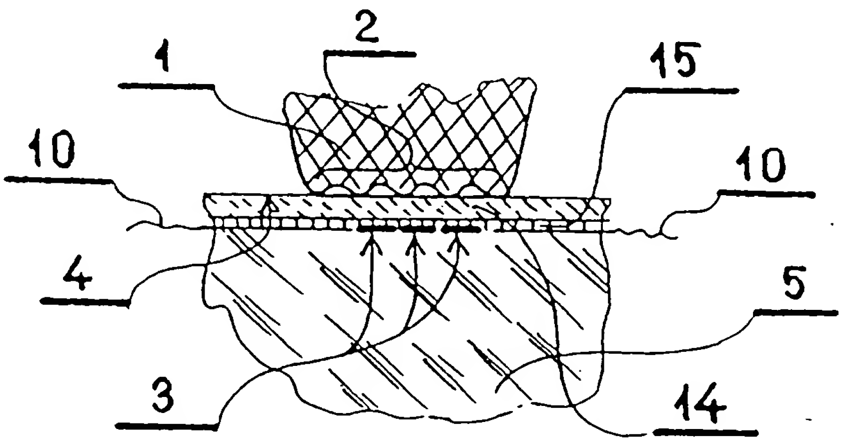
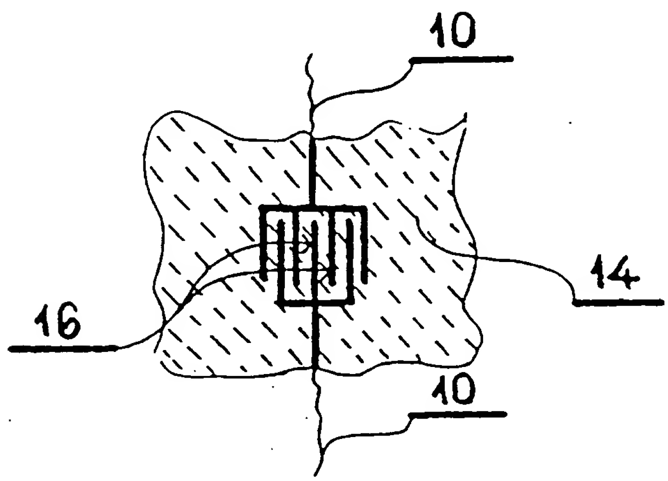



Fig. 4.

Fig. 5.



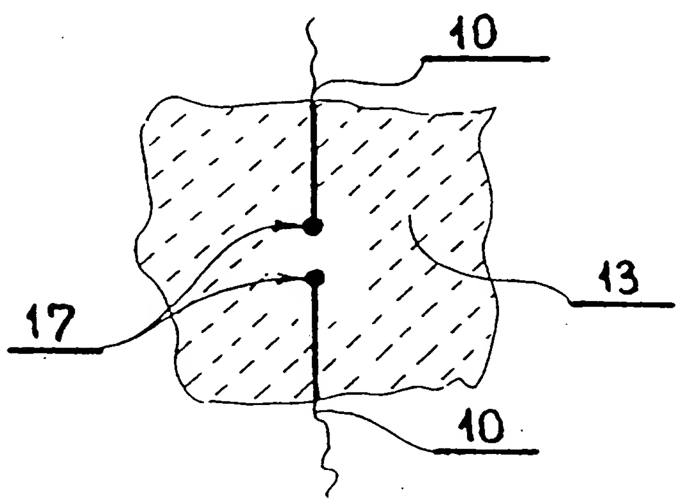




Fig. 6.

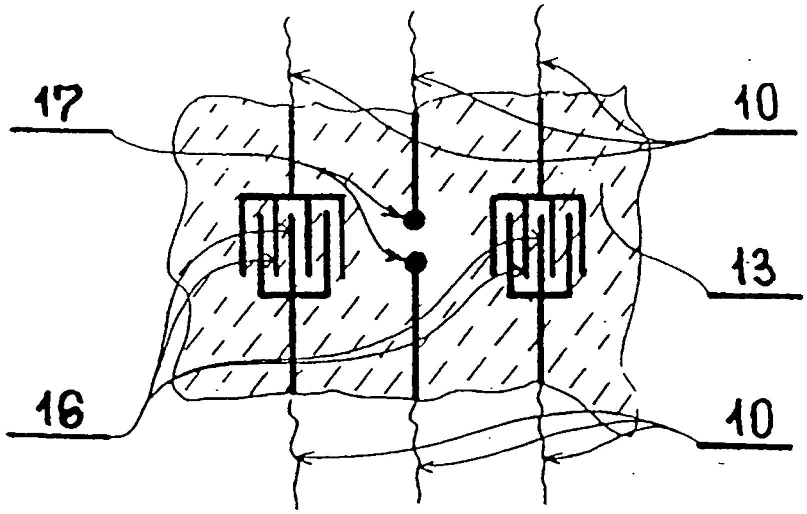



Fig. 7.

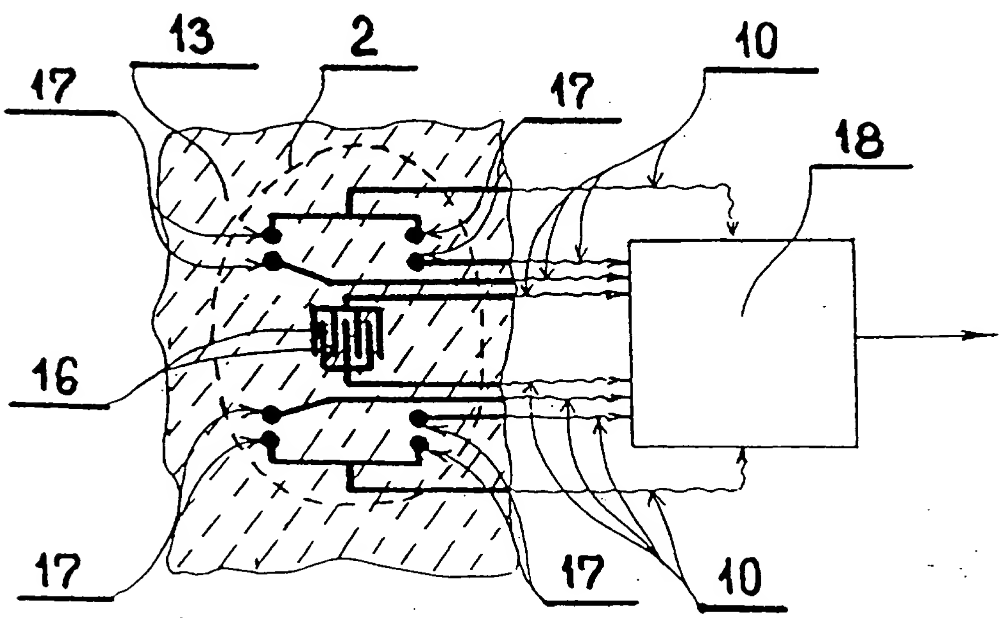



Fig. 8.

# INTERNATIONAL SEARCH REPORT

Intern  nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06K9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | EP,A,0 359 554 (FUJITSU LTD) 21 March 1990<br>see column 1, line 60 - column 2, line 10; figure 34<br>--- | 1-12 |
| A | FR,A,2 674 051 (GEMPLUS CARD INT) 18 September 1992<br>see abstract<br>see page 7, line 9 - line 26<br>----- | 1-12 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Information on patent family members

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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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